Validity And Practicality of PBL-Based Student e-Worksheets in Improving Physics Problem-Solving Skills

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Abstract - *Problem-solving skills are an important factor in physics learning. Efforts to improve problem-solving skills in physics require PBL-based electronic worksheets. This study aims to develop a valid and practical PBL-based electronic worksheet to improve physics problem-solving skills in the context of global warming. This type of research is development research that follows the research model developed by Thiagarajan, which consists of 4 stages: define, design, development, and dissemination. The PBL-based electronic worksheets development method to improve problem-solving skills in this research and development consists of 3 stages: the define stage, used to analyze student and teacher needs for PBL-based electronic worksheets; curriculum analysis; data analysis of student skills in solving physics problems; and searching for articles related to problem-solving skills. At this stage, data on students' problem-solving skills and the importance of electronic worksheets in physics learning are collected. The design stage is used to create the electronic worksheets' design. At this stage, a problem-based electronic worksheet design is produced. The development stage involved validity tests conducted by 3 experts: 2 physics education lecturers and 1 physics teacher. At this stage, a valid PBL-based electronic worksheet was produced, as indicated by an average content validity of 4.31 and construct validity of 4.32, categorized as valid. The next test was the practicality of the PBL-based electronic worksheets. The practicality test was conducted by implementing the electronic worksheets with students studying global warming. This stage resulted in practical electronic worksheets, as indicated by an average implementation rate of 86% and Positive student responses (77%) stating that electronic worksheets were easy to understand. In comparison, 23% of students said electronic worksheets were a bit difficult to understand. This indicates that the PBL-based electronic worksheets are easy for teachers to implement and can be used by students in physics learning.*

Keywords: Validity, practicality, e-worksheets, problem solving

INTRODUCTION

The 21st-century era of globalization requires proficiency in knowledge and skills that must be possessed and mastered by individuals to produce superior, competitive human resources, one of which is in the field of education (Distrik et al., 2022; Rohman et al., 2020). The world of education must be ready to face changes and developments in science and technology, so that it can prepare the next generation who are skilled to compete in a more advanced world (Bishop et al., 2020; Huang et al., 2019; Rohman et al., 2019). Efforts that can be made include continuing to improve the existing curriculum. The educational curriculum is dynamic because its development adapts to students' characteristics and needs over time (Duc Dat et al., 2024).

Meaningful learning can be achieved through an effective learning process, which can be achieved by identifying the right learning model, with the use of teaching materials as one of the main supports (Apriyani et al., 2022; Distrik et al., 2020) . Learning can be more meaningful when using the right teaching materials. Therefore, teaching materials must be high-quality, interesting, fun, and up-to-date (Distrik et al., 2019). One initiative to advance the learning process is the development of high-quality teaching materials that instill values of understanding, character, and national

culture in line with the times. The development of the times in the 21st century, which occupies the era of industrial change 4.0, leads to the rapid development of technology and information, thus becoming a challenge for the government and executives to improve the quality of learning (Pane et al., 2021)

Indonesia has shown its efforts to improve the quality of education, one of which is the emergence of the Merdeka Curriculum, which centers on the concept of freedom of thought. The Merdeka Curriculum prioritizes the concept of "Merdeka Belajar" for students, designed to help address the learning crisis caused by the COVID-19 pandemic. The use of technology and competency needs in the current era are one of the foundations for the development of the Merdeka Curriculum (Fauzan et al., 2023). The increasingly widespread use of technology and other programs planned by the government, such as Movers Schools, Movers Teachers, SMK Centers of Excellence (SMK-PK), and so on, are among the government's efforts to implement the Merdeka Curriculum and recover from the learning crisis. Learning in the independent curriculum is more directed and emphasizes students' needs (student-centered). The independent learning curriculum is a response to the intense global competition for human resources in the 21st century(Suyatna and Rohman, 2025).

Education in the 21st century requires students to have a broad mindset. Learners are required to possess four abilities: critical thinking and problem-solving, communication, creativity and innovation, and collaboration (Rohman & Lusiyana, 2017; Yohandri et al., 2020) (Distrik et al., 2024). 21st-century skills are an important component of students' learning because they play a role in the learning process; therefore, students must master them in the world of education as a prerequisite for entering the world of work. One of the skills learners need in the 21st century is problem-solving. A PBL-based learning model is considered capable of facilitating students' development of 21st-century skills. PBL is more effective in helping students improve Problem-Solving Skills. Arend's research (Fathonah et al., 2024; Susanti et al., 2021) shows that PBL helps develop lifelong learning skills within an open, reflective, critical, and active learning mindset. The problems that exist are sourced from the reality around them and pose challenges for students to identify. Based on this process, the PBL learning model is implemented systematically by building students' skills through problem identification and problem-solving, especially in physics learning (Pane et al., 2021). The use of the PBL model will be maximized if it is collaborated with the use of learning media, both in the form of simple and technology-based media (Umriani et al., 2020)

One medium that can support Problem-Solving Skills is the Learner Worksheet (Ramadhan et al., 2020). Learner Worksheet is one of the teaching materials created by teachers to help students learn and explore the concepts of a material, so that students are actively involved in classroom learning activities (Lee et al., 2017). Learner Worksheets can be presented in printed or electronic form (Ilana & Cintamulya, 2022). The selection of the Learner Worksheet type to be used must be adjusted to current conditions and student needs.

Regarding the expected form of the worksheet, Saputri et al. (2025) summarized findings from various studies that an innovative e-Worksheet is needed by students in both face-to-face and online learning. An e-Worksheet is very useful in face-to-face learning to overcome student boredom because it offers various features

and can present additional information more easily through internet access. In this case, an e-Worksheet is a worksheet that can make it easier for students to understand material in electronic form, and it can be used on computers, laptops, cellphones, and other devices (Amalia et al., 2019). The use of e-Worksheet will make students more active learners because they discover the concepts they learn.

The use of PBL-based e-Workbooks can serve as an alternative teaching material. One of them is a web-based Learner Worksheet, namely Nearpod, which can be accessed through https://nearpod.com/. This Nearpod-assisted Learner Worksheet uses technology to make learning interactive among students and between students and teachers. Nearpod is a web-based application that requires an internet connection and can be used on mobile phones and laptops without installation, and it can be used independently by students. Nearpod can maximize learning by displaying text, audio, images, videos, and assessments in engaging quizzes. The assessment of nearpod-based quiz results includes a feature that sets a time limit for each test question, minimizing cheating during the evaluation and allowing test scores to be announced quickly. Based on preliminary research conducted by distributing needs analysis questionnaires to several teachers at SMAN 7 Bandar Lampung, the data obtained indicate that learning with the PBL model has not been fully implemented. In addition, it is also known that teachers in learning activities have not optimally provided learning media in the form of Learner Worksheet to students, and for e-Worksheet, have never been given to students, only using Learner Worksheet in printed form, so that they are less varied and less interesting to learn, and students tend to get bored. Based on the results of the needs analysis, it is also known that teachers really need learning media in the form of e-Workbooks that apply the PBL model to support learning activities that make students more active, reduce the likelihood of boredom during the learning process, and improve students' Problem-Solving Skills. The results of a preliminary study conducted by researchers who distributed questionnaires to several students revealed that classroom learning was less engaging because the teacher's instructional model and media did not fully involve students in an active role. Some students also reported that during the learning process, they had not fully used the Learner Worksheet and that the teacher had never given the e-Worksheet.

Based on preliminary research, students need more Learner Worksheets to solve physics problems, as the problems presented in the Learner Worksheets are more easily understood by students. The problem-solving-based learner worksheet is very useful for students. Learning should be implemented when the teacher directs students to solve problems. Solving problems should be required to explain the concept first. If the concept is explained well, then the problem-solving is good, and vice versa. In fact, in physics learning, teachers very rarely teach students to solve problems. As a result, the students' Problem-Solving Skills learning outcome is very low. This is because students' physics Problem-Solving Skills are low. Problem-solving is very important to learn, especially in physics, because physics is essentially problem-solving. Therefore, a teaching material that provides exposure and makes problem-solving easier is needed. One of them is electronic-based teaching materials, namely, PBL-based e-Worksheet.

Based on preliminary research conducted at SMAN 7 Bandar Lampung, the

unavailability of a PBL-based e-Worksheet using the Nearpod platform to improve students' problem-solving skills is the basis for this research titled "Development of PBL-based e-Worksheet to improve physics problem-solving skills."

RESEARCH METHODS

The focus of this research is the development of a PBL-based e-Worksheet to improve physics Problem Solving Skills. This study used a Research and Development (R&D) research design in the product development research category, adapted from Thiaragajan (1974). Research and Development (R&D) research design is a systematic design involving several stages of the 4D development model, including the define, design, development, and disseminate stages based on empirical research. However, this development research is only carried out up to the development stage.

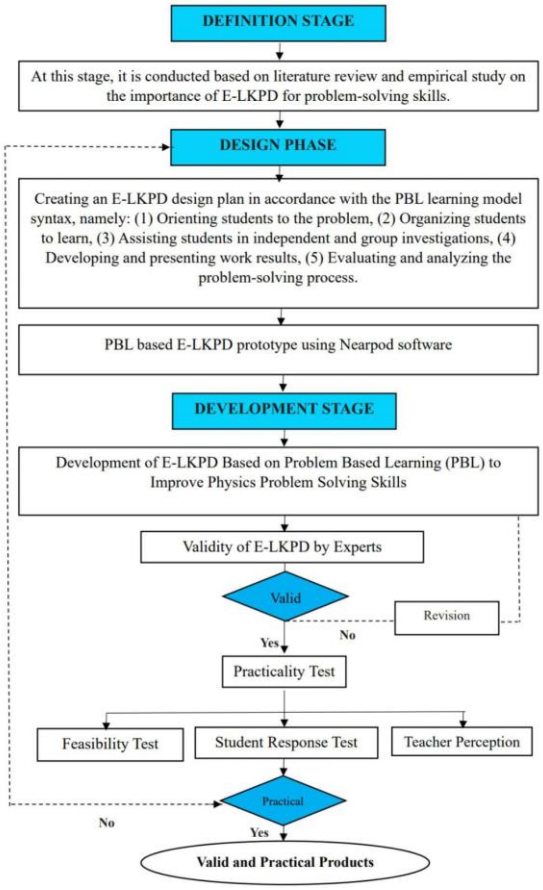

Figure 1. Flowchart of Development Research

This research was conducted in the 2024/2025 academic year at SMAN 7 Bandar Lampung. The research was conducted with even-semester class X students who used the independent curriculum. The research methods used include observation, a questionnaire, and a validation sheet. The research instrument is used to analyze data obtained through measurement, with validation instruments from experts to evaluate the feasibility of the e-Worksheet and student questionnaires to assess its practicality. The validation sheets were analyzed using qualitative and quantitative approaches. Quantitative data were collected from respondents' Likert-scale responses, with each statement assigned a value according to the provisions in Table 1.

Table 1. Likert Scale on Product Validation Sheet.

Qualification	Score Criteria
Very good	5
Good	4
Good enough	3
Not good enough	2
Very poor/None	1

The validity data analysis in this study will be carried out by calculating the score interval from the assessment results. After being calculated, the data is categorized into several levels: very valid, valid, quite valid, less valid, or invalid.

Table 2. Conversion of Product Validity Assessment Score.

Score Interval	Criteria
4,21 - 5,00	Very valid/very good
3,41 - 4,20	Valid/Good
2,61 - 3,40	Quite valid/Moderately improved
1,81 - 2,60	Less Valid / Not good
1,00 - 1,80	Not Valid / Not good

Meanwhile, the data analysis used to determine the product's practicality in this study was based on responses to the

implementation test questionnaire, the student response test, and the teacher perception test. The results of the questionnaire answers will be analyzed using percentage analysis, based on the formula given by Sudjana (2005), as follows.

$$\%X = \frac{\sum Score\ obtained}{\sum maximum\ score} \times 100\%$$

The data from the e-Worksheet implementation test questionnaire were analyzed using criteria adapted from Sugiyono (2015), as listed in Table 3 below.

Table 3. Practicality Test Score Conversion

Average Score	Precentage	Criteria
1,00 – 1,75	25% - 43,75%	Not practical / Not good
1,76 – 2,50	43,76% - 62,50%	Less practical / Less good
2,51 – 3,25	62,51% - 81,25%	Practical / Good
3,26 – 4,00	81,26% - 100%	Very practical / Very good

Sugiyono (2015)

RESULTS AND DISCUSSION

Results

The results of this research and development only demonstrate the validity and practicality of the PBL-based e-Worksheet. Product validity comprises content and construct validity, while the e-Worksheet implementation in learning and by student and teacher responses determines practicality. Product content and construct validity are shown in Tables 4 & 5.

Table 4. Content Validity e-Worksheet

Assessment aspect	Content Validity Validator			Average
	1	2	3	
Material structure	4,15	4,21	4,16	**4,17**
Social system	4,31	4,5	4,46	**4,42**
Reaction principle	3,82	4,17	4, 02	**4,00**
Reaction principle	4,4	4,61	4,5	**4,50**
Supporting system	4,52	4,36	4,41	**4,43**
Average	**4,24**	**4,37**	**4,38**	**4,31**

Table 5. Construct Validity e-Worksheet

Assessment aspect	Contruct Validity Validator			Average
	1	2	3	
Originality	4,38	4,41	4,37	**4,39**
Language	4,31	4,34	4,34	**4,33**
Design	4,21	4,3	4,25	**4,25**
Average	**4,30**	**4,35**	**4,32**	**4,32**

Feasibility refers to the extent to which the e-Worksheet can be effectively implemented in a physics learning context, including ease of use by teachers and the availability of materials. On the other hand, student responses provide insight into their perceptions and reactions to the e-Worksheet. The practicality of the e-Worksheet is shown in Table 6.

Table 6. e-Worksheet implementation observation result

Observation Aspects	Observer		Average
	1	2	
Activity steps	4.3	4.4	**4.35**
Principle of reaction	4.4	4.3	**4.35**
Social system	4.3	4.2	**4.25**
Supporting system	4.3	4.4	**4.35**
Instructional effect	4.3	4.6	**4.45**
Average	**4.32**	**4.38**	**4.35**

After the learning was completed, the students' response to the PBL-based e-Worksheet in physics learning was positive, namely 77% of students stated that the e-Worksheet was quite easy to understand and access to images and videos is quite easy.

Discussion

The development of valid and practical Problem-Based Learning (PBL) electronic worksheets represents a crucial step toward enhancing 21st-century competencies, particularly problem-solving skills in physics education. The findings of this study demonstrate that the developed e-worksheets met the criteria for content and construct validity, as well as for practicality in classroom implementation. These results align with and extend the existing body of knowledge on technology-integrated pedagogical tools.

Validity of the Developed PBL-Based E-Worksheets

The high content validity score (4.31) indicates that the e-worksheet's structure faithfully adheres to the core syntax of the PBL model. The systematic presentation, which begins with problem orientation through video media, then organizes students for learning, guides inquiry, and develops and presents work, reflects a well-structured cognitive tool. This design is theoretically grounded in cognitive learning theory, which posits that learning is an active process of constructing meaning from experience (Piaget, 1954). By confronting students with an ill-structured problem related to global warming, the e-worksheet activates their prior knowledge and creates a cognitive conflict that motivates further exploration (Hmelo-Silver et al., 2007). Furthermore, the constructivist elements are evident, as students are not passive recipients of information but are actively engaged in building their own understanding through investigation and collaboration. This finding corroborates the research by (Distrik et al., 2022), who found that digital problem-based worksheets significantly enhance conceptual understanding by promoting active knowledge construction.

The construct validity score of 4.32 confirms that the e-worksheet is well-designed in terms of language, presentation, and alignment with learning objectives. The clarity of instructions and the logical organization of materials are critical factors that reduce extraneous cognitive load, allowing students to focus on the essential aspects of problem-solving (Huda et al., 2025). The positive evaluation of the "supporting system" aspect, which includes accessibility of images, videos, and the Nearpod platform itself, underscores the importance of selecting appropriate technology. As noted by Amalia et al. (2019), the use of interactive platforms like Nearpod can make learning more dynamic and engaging, which is crucial for sustaining student interest in complex topics like physics. The validators' assessment confirms that the e-worksheet successfully integrates pedagogical principles with technological features to create a coherent learning experience.

Practicality and Implementation in Physics Learning

The practicality of the PBL-based e-worksheet was evidenced by its high implementation rate (87%) and predominantly positive student responses. The observation data, with an average score of 4.35 across all activity steps, suggests that teachers and students could navigate the worksheet's activities without significant procedural obstacles. This ease of implementation is a key factor for the successful adoption of any educational innovation (Suyatna and Rohman, 2025; Novela et al., 2025). The structured guidance in the e-worksheet likely empowered teachers to serve as effective facilitators, guiding students through the inquiry process rather than merely delivering content. The high "instructional effect" score (4.45)

reported by the second observer further suggests that the learning process was perceived as effective in achieving its intended goals.

The positive student response, with 77% finding the e-worksheet easy to understand and access, is a vital indicator of its user-friendliness. This aligns with the findings of Apriyani et al. (2022), who reported that well-designed e-worksheets can enhance students' self-efficacy and engagement. The integration of multimedia elements such as videos and interactive quizzes within the Nearpod platform likely contributed to this positive reception, making abstract physics concepts related to global warming more concrete and relatable. However, the feedback from the remaining 23% of students who found the worksheet "somewhat difficult to understand" warrants attention. This difficulty may stem from individual differences in digital literacy, reading comprehension levels, or prior knowledge of the topic (Distrik et al., 2024; Sedayu et al., 2024; Wayan Distrik et al., 2021). This finding underscores the importance of differentiated instruction and suggests that, while the e-worksheet is practical for most students, teachers should be prepared to provide additional scaffolding for those who need it. Future iterations of the product could include embedded scaffolds, such as pop-up definitions for key terms or tiered questioning, to accommodate a wider range of learners.

In conclusion, the PBL-based e-worksheet developed in this study is a valid and practical tool for teaching physics, particularly global warming. It successfully translates the theoretical principles of PBL into a tangible, technology-enhanced learning environment that facilitates student-centered inquiry. The positive results provide a strong foundation for the next stage of research: evaluating its effectiveness in directly and measurably improving students' physics problem-solving skills.

CONCLUSION

This study has successfully developed a Problem-Based Learning (PBL) electronic worksheet on global warming, designed to enhance physics problem-solving skills among high school students. The product was declared valid based on expert assessments, with an average content validity score of 4.31 and a construct validity score of 4.32, both falling into the "highly valid" category. These results confirm that the e-worksheet structurally adheres to the PBL syntax and is well-designed in terms of language, presentation, and alignment with learning objectives. Furthermore, the e-worksheet proved practical for classroom implementation, as evidenced by an 87% implementation rate during learning activities and by positive responses from 77% of students who found it easy to understand and access. This indicates that the developed product can be seamlessly integrated into physics instruction without significant obstacles, offering educators a reliable and engaging tool to foster student-centered learning.

Despite these promising findings, this study was limited to the development and practicality testing phases and did not measure the product's direct effectiveness in improving students' problem-solving skills. Additionally, the feedback from 23% of students who experienced some difficulty suggests the need for further refinement to accommodate diverse learner needs. Therefore, future research is recommended to conduct experimental studies to evaluate the e-worksheet's impact on problem-solving abilities quantitatively and to explore its implementation across broader educational contexts. Such efforts will

significantly prepare students with the essential competencies needed to navigate the complex challenges of the 21st century.

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